Geophysical Research Abstracts
Vol. 19, EGU2017-2290, 2017
EGU General Assembly 2017

Mass Extinctions of Pangea (Jean Baptiste Lamarck Medal Lecture)

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The 80 million years of Earth history from middle of the Permian to the early Jurassic were some of the worst life ever experienced. The interval includes two mass extinctions that bracket the Triassic period and several lesser crises. It was to be nearly another 120 million years before another major crisis was to strike (this time it was the famous one that removed the dinosaurs). So what was so bad about the 80 million years and why was it so good afterwards? My talk will try to provide at least some of the answers. There are plenty of clues. Notably, the interval coincides with the presence of the Pangea supercontinent and all the extinctions coincided with the eruption of large igneous provinces (LIPs). Indeed, every LIP of this interval coincides with an extinction crisis, a perfect correlation that completely breaks down afterwards. However, getting from correlation to causation is far from straight forward. There are many unknowns – how much gas was released by the volcanism, how quickly and what type of gases were they? These are all questions under investigation.
Most of the extinctions of Pangean time coincide with rapid global warming and extensive marine anoxia suggesting that greenhouse gas emissions linked to volcanism were an important extinction driver. For the most severe crises (Permo-Triassic and end-Triassic) losses occurred throughout the food chain all the way down to the primary producers of the oceans and across all habitats including terrestrial ecosystems. At the other end of the spectrum of disaster, the lesser extinctions (Toarcian, Smithian/Spathian) only affected marine invertebrates. The full panoply of catastrophe was played out during the Permo-Triassic mass extinction and has received the most attention. The record in South China shows that there were two phases of extinction. These straddle the boundary and show selective losses initially for shallow-water organisms that were susceptible to high temperatures and then for deeper-water dwellers that succumbed to expanding deep-water anoxia. The contemporary plant losses show a similar duration for extinction losses (∼60 kyr) but the ultimate cause of these extinctions is less clear. It is unlikely to have been directly attributable to greenhouse gases because warm and wet conditions on land are a good thing. A greenhouse is a good place for plants after all. Ozone destruction by halogen emissions followed by intense UV-B radiation is a more promising extinction agent.
A key factor in the extinction vulnerability of Pangean life may lie in the subdued nature of carbon cycling in a supercontinent configuration. Feedback mechanisms such as enhanced silicate weathering in warmer, more humid conditions would be less effective because of the vast arid interiors. The burial of carbon in shelf seas would also be minimal because the area of shallow waters around the periphery of the supercontinent was at a Phanerozoic minimum. Once initiated, warmer temperatures would have led to increased rate of organic remineralisation. This may have been responsible the absence of terrestrial organic carbon burial during the most severe crises, further decreasing the ability to drawdown atmospheric carbon. This combination of causes would have produced a planet that was only weakly responsive to sudden influxes of greenhouse gases into the atmosphere. It was a bad time to endure LIP eruptions.